

SPACE WEATHERING OF OLIVINE IN LUNAR SOILS: A COMPARISON TO ITOKAWA REGOLITH SAMPLES.

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Introduction: Regolith particles from airless bodies preserve a record of the space weathering processes that occurred during their surface exposure history. These processes have major implications for interpreting remote-sensing data from airless bodies. Solar wind irradiation effects occur in the rims of exposed grains, and impact processes result in the accumulation of vapor-deposited elements and other surface-adhering materials. The grains returned from the surface of Itokawa by the Hayabusa mission allow the space weathering “style” of a chondritic, asteroidal “soil” to be compared to the lunar case. Here, we present new studies of space-weathered olivine grains from lunar soils, and compare these results to olivine grains from Itokawa.

Samples and Methods: We analyzed microtome thin sections of olivine grains from the 20-45 μm fractions of three lunar soils: 71061, 71501 and 10084 (immature, submature and mature, respectively). Imaging and analytical data were obtained using a JEOL 2500SE 200kV field-emission scanning-transmission electron microscope equipped with a thin-window energy-dispersive x-ray spectrometer. Similar analyses were obtained from three Hayabusa olivine grains [1].

Results and Discussion: We observed lunar grains showing a range of solar flare track densities (from $<10^9$ to $\sim 10^{12} \text{ cm}^{-2}$). The lunar olivines all show disordered, highly strained, nanocrystalline rims up to 150-nm thick. The disordered rim thickness is positively correlated with solar flare track density. All of the disordered rims are overlain by a Si-rich amorphous layer, ranging up to 50-nm thick, enriched in elements that are not derived from the host olivine (e.g., Ca, Al, and Ti). The outmost layer represents impact-generated vapor deposits typically observed on other lunar soil grains [2].

The Hayabusa olivine grains show track densities $<10^{10} \text{ cm}^{-2}$ and display disordered rims 50- to 100-nm thick [1]. The track densities are intermediate to those observed in olivines in immature and submature lunar soils and indicate surface exposures of $\sim 10^5$ years [3]. The outermost few nanometers of the disordered rims on Hayabusa olivines are more Si-rich and Mg- and Fe-depleted relative to the cores of the grains and likely represent a minor accumulation of impact-generated vapors or sputter deposits [1]. Nanophase Fe metal particles are less abundant in the Hayabusa rims compared to the rims on lunar grains.

Conclusions: The Hayabusa and lunar olivine grain rims have widths and microstructures consistent with formation from atomic displacement damage from solar wind ions. The space weathering features in the Hayabusa grains are similar to those observed in olivines from immature to submature lunar soils. A major difference, however, is that the Hayabusa grains appear to lack the hypervelocity impact products (melt spherules, thick vapor deposits, and abundant nanophase Fe metal particles) that are common in lunar soil grains with a similar exposure history.

References: [1] Keller, L. P. & Berger, E. L. (2014) *LPSC XLV*, #1935. [2] Keller, L. P. & McKay, D. S. (1997) *GCA*, 61, 2331. [3] Berger, E. L. & Keller, L. P. (2014) Goldschmidt Conf., #180.